



# URBAN INDICATORS OF CLIMATE CHANGE

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Report from the  
Center for Health and the Global Environment,  
Harvard Medical School and  
The Boston Public Health Commission

PUBLISHED BY:

THE CENTER FOR HEALTH AND THE GLOBAL  
ENVIRONMENT

Harvard Medical School  
Landmark Center  
401 Park Drive  
Boston, MA 02115

And

THE BOSTON PUBLIC HEALTH COMMISSION

1010 Massachusetts Avenue  
Boston, MA 02118

August 2003

The collaborative work and this report were supported by the Harvard Medical School, the Boston Public Health Commission, and a grant from The John Merck Fund, a thought leader in the field of health and the environment.

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# URBAN INDICATORS OF CLIMATE CHANGE

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## EXECUTIVE SUMMARY

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### Background

Collaboration between the Center for Health and the Global Environment at Harvard Medical School and The Boston Public Health Commission began in 1998, in order to bring public health concerns related to climate change and energy policies to the fore within the City of

Boston. In 2001 Boston Mayor Thomas M. Menino adopted a goal of reducing the City's energy use by 10% by 2005 and, under his leadership, the US Conference of Mayors passed a resolution regarding climate change and public health at its annual meeting in June, 2002.

In October 2002, key policymakers from health departments in major U.S. cities came together to begin to answer the following questions:

1. What role can city health departments play in addressing the issue of climate change?
2. What are the most appropriate organizational and programmatic responses?

From advocacy to education, response to prevention, what tools do health departments have, and what are potential barriers?

After a vigorous day and a half of discussion, there was a real commitment from the group to pursue a public health-climate protection agenda on the national level, to work together to set public health indicators, and to promote preventative strategies.

This report is based on the proceedings of that conference.



### Overview

The issue of climate change poses new challenges, and new opportunities for the field of public health. While the potential health impacts are distressing — asthma and other respiratory illnesses, infectious diseases, heat stress, heart disease — the preventative

strategies include measures that could simultaneously improve air quality and enhance the livability of urban communities.

Combustion of fossil fuels — oil, coal and natural gas — is responsible for air pollution and climate change, and air quality is a particular problem for urban centers worldwide. Traffic patterns and automotive exhaust, power plants, airports and industrial emissions are the primary sources, while wind patterns can bring in pollution and unhealthy air masses originating in other regions.

Allergens (molds and pollen) originating in rural urban areas can reach high levels in highly populated cities.

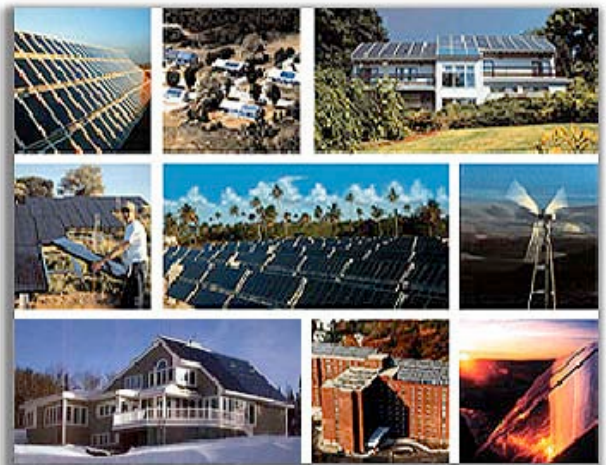
The impacts of air pollution can be compounded by extreme weather events, whose intensity and frequency is increasing as climate changes. These include more heatwaves, drought-driven fires, floods and the impacts of warming are exacerbated by “the heat island effect”.

This report examines the direct impacts of climate change in cities, synergies between air pollution and climate change, and connections between climate change and emerging infectious diseases — in particular, West Nile virus, the primary vectors (carriers) of which breed in urban areas.

This report is intended as a guide for City Health and Environmental Departments, for broadcast and press meteorologists, and for City policy makers, in order to better monitor and assess the health impacts of climate change in cities and formulate adaptive and preventive solutions.

## Key Points

1. **Photochemical smog** (ground-level ozone) is a product of reactions between tailpipe emissions – oxides of nitrogen ( $\text{NO}_x$ s) and volatile organic compounds (VOCs) -- and the chemical reaction is accelerated during heatwaves. Heatwaves are intensified and prolonged with climate change.
2. **Heatwaves**, unhealthy air masses, high heat indices (a function of temperature and humidity), plus lack of nighttime relief all affect cardio-respiratory illness and mortality.
3. Increased humidity and nighttime temperatures (daily minimums) are associated with a changing climate.
4. The **Heat Island Effect** can raise ambient temperatures in urban centers as much as 7°F over those in surrounding rural areas.
5. Roof gardens, urban parks, tree-lined streets, “smart growth,” and improved pedestrian, bicycle and public transport can reduce the “Heat Island Effect.”
6. **Ragweed** (in vacant lots and other disturbed areas) **pollen** and **tree pollens** (e.g., maples, birches, poplars) are stimulated by increased carbon dioxide ( $\text{CO}_2$ ), and by warmer winters and early arrival of spring.
7. Reduced combustion of fossil fuels and reforestation will reduce  $\text{CO}_2$  levels.
8. **Particulates**, carbon monoxide ( $\text{CO}$ ), **ground-level ozone** and carcinogenic polycyclic aromatic hydrocarbons (PAHs) from drought-driven wildfires can affect populations living far from the fires.
9. Forestry practices (e.g., thinning of small trees) and reduced fossil fuel burning can reduce the vulnerability and propensity to drought-driven fires.
10. **Floods** can directly affect coastal and riverside cities, and floods and higher humidity foster fungal growth in houses.
11. Fungal growth inside houses can affect respiratory health and alter insurance coverage.
12. The avian-mosquito cycle of **West Nile virus** (WNV) is amplified by spring droughts and summer heatwaves; as bird-biting, urban-dwelling mosquitoes (*Culex pipiens*) breed in city drains with organically-rich litter (e.g., leaves) in the shallow pools that remain even during droughts.
13. Early warning systems of conditions conducive to large outbreaks of WNV can facilitate environmentally-friendly public health interventions.
14. **Severe and erratic weather** – early and late snowstorms, ice storms and dense fog – present hazards for automotive drivers and pedestrians.
15. Climate forecasting can affect travel plans and driving precautions.
16. **Severe storms** in coastal cities (intensified by sea level rise) can damage infrastructure, such as water and sanitation systems, with wide-ranging implications for public health.
17. Developing alternatives to fossil fuels is fundamental for the protection of public health and for maintaining environmental and economic stability.



## INTRODUCTION

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In October 2002, the Boston Public Health Commission and the Center for Health and the Global Environment at Harvard Medical School brought together fifteen high-level representatives from major U.S. cities to discuss the links between public health and climate change, and the role municipal health departments can play. The complete participant list can be found in Appendix A.

The goal was to begin to outline mechanisms to mitigate dangerous public health impacts from climate change, as well as monitor and respond to these threats.

Prior to the forum, participants received a briefing packet with background scientific studies, as well as materials on local health department policies and projects related to climate change.



Dr. John Rich of BPHC

The first evening of the forum was a dinner meeting to allow for participants to get to know each other in an informal setting. The facilitator asked participants to identify why the forum topic was important to their health department, and what they were hoping to take

home from the forum. The facilitator made note of these priorities, and worked to include them in the next day's discussion.

The following morning, participants convened at the Boston Public Health Commission. The day began with a presentation by Dr. Paul Epstein providing an overview of climate science, and the analytical pathways relating the issue to public health. After the presentation, city health directors asked questions and discussed the ways that climate change could impact public health in their communities.

The facilitator then provided an opportunity for participants to hear from each other about the various efforts that were underway. Participants were asked to identify some of the barriers that they had already encountered, or feel they would encounter when attempting to work on climate change at their departments. Recommendations were encouraged throughout.

During the afternoon session, participants began to outline key recommendations and action steps to pursue after the forum.

The success of the forum can be attributed, first and foremost, to the enthusiastic and thoughtful contributions of the participants. Credit is also due to the talented and focused facilitation of Dr. Jean McGuire.

The following is the proceedings from this landmark forum.

## BACKGROUND

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By the late 1990s, asthma rates in inner city Boston neighborhoods had reached epidemic levels. The Boston Public Health Commission was inundated by residents' concerns about air pollution and its affect on asthma and other health issues within the community. Boston health officials were also becoming aware that the scientific community had concluded that fossil fuel consumption was dramatically altering the global climate. As researchers, like Dr. Paul Epstein at the Center for Health and the Global Environment at Harvard Medical School, began to document the way that these environmental changes could impact human health, it became clear that Boston residents were at risk. Studies showed that climate change could entail hotter summer days, more polluted skies, and new vector-borne diseases for Boston. This alarming discovery, compounded by the current air quality issues facing the city, strengthened the resolve of Boston health officials to address energy policies at the root of these problems.

In October 1999, the Boston Public Health Commission (BPHC) and the Center for Health and the Global Environment (CHGE) launched the *Healthy Cities Initiative*, a joint effort to find local solutions to health impacts associated with air pollution and global climate change. The premise was that these two synergistic issues had a common source — fossil fuels — and a similar set of preventive strategies, many of which could be implemented on the local level. The Healthy Cities

Initiative worked to motivate concern for energy-related health impacts, and to organize efforts to increase energy efficiency and the use of cleaner energy in the city of Boston.

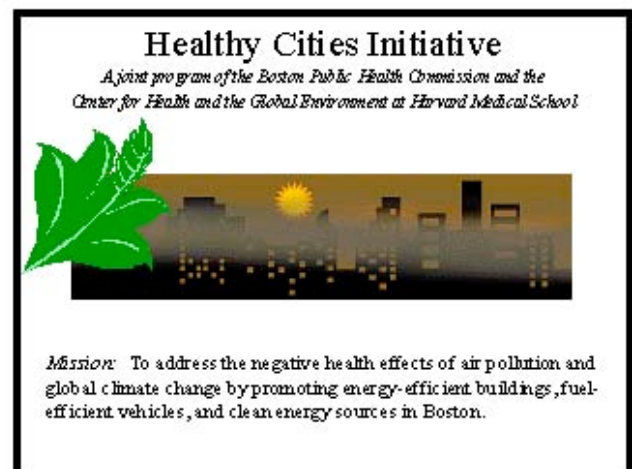
Influencing energy policies with the aim of preventing climate-related health problems proved to be challenging work. For one thing, the Boston community, including city officials, did not have the same level of understanding and experience with climate change as they did with other environmental health threats. Air pollution work, for instance, benefited from a wealth of local scientific studies, mitigation pilot projects, and educational campaigns. BPHC had to spend time establishing the scientific and political basis for their concern. BPHC found it difficult to advocate

for political and financial capital to be spent on a future threat, when the national government, and the public at-large, wasn't making it a priority. The widespread nature of climate protection interventions — household energy consumption, building construction, electric utility deregulation — also posed jurisdictional challenges for the BPHC as it became involved in arenas where other agencies had historically taken the lead.

The BPHC felt that they had entered uncharted territory. They realized that there were significant gaps in their understanding of how the issue of climate change should be addressed at their organization, and in the public health field at-large. With no resources or guidance coming from national health agencies, the BPHC was eager to learn if and how other city health departments were thinking about the issue. What sort of barriers were they facing? What kind of strategies were they implementing?

The desire for advice and input from other city health directors, and the hope that collaboration could spur greater support for this work at both the local and national levels, motivated the BPHC and CHGE to launch a national dialogue. In August 2002, they began to organize a forum where city health directors could share their experiences, and identify ways to move the climate protection agenda forward, both on the local level and in other strategic arenas.

In October 2002, high-level representatives from fifteen urban health departments around the country convened in Boston to begin this work.



## SCIENCE OF CLIMATE CHANGE AND IMPLICATIONS FOR PUBLIC HEALTH

The U.S. National Assessment of the Impacts of Climate Change and Variability projects that there will be changes in the climate and in weather patterns in every region of the United States as a result of increasing atmospheric concentrations of greenhouse gases. These predictions are in keeping with those of the U.N. Intergovernmental Panel on Climate Change for the planet as a whole. The rise in atmospheric greenhouse gas concentrations is due to human activities, primarily the production and consumption of fossil fuels, which emit carbon dioxide.

Changes will involve warming temperatures — with the largest increases occurring geographically at higher altitudes and latitudes, and during the winter and at night — and an increase in extreme weather events, with heavy rains and flooding in some areas and drought in others. The warming, sea level rise and extreme weather events are projected to have major impacts on urban infrastructure, air quality, asthma and other respiratory illnesses, heat stress and heart disease, emerging infectious diseases (e.g., West Nile), and travel hazards related to erratic and severe weather.

Cities could face a complicated web of environmental health threats as a result of these projected changes. For example, higher summer temperatures could aggravate urban heat island effects, causing heat stress that leads to increased electricity use for refrigeration and cooling systems, which, in turn, generate air pollution. In addition, nitrous oxides from cars and trucks develop into ozone more quickly in hotter temperatures, increasing the burden for individuals with respiratory and cardiovascular health problems. Respiratory stress could be further aggravated by smoke from forest fires caused by drought, and by high pollen counts from increased CO<sub>2</sub> in the air.

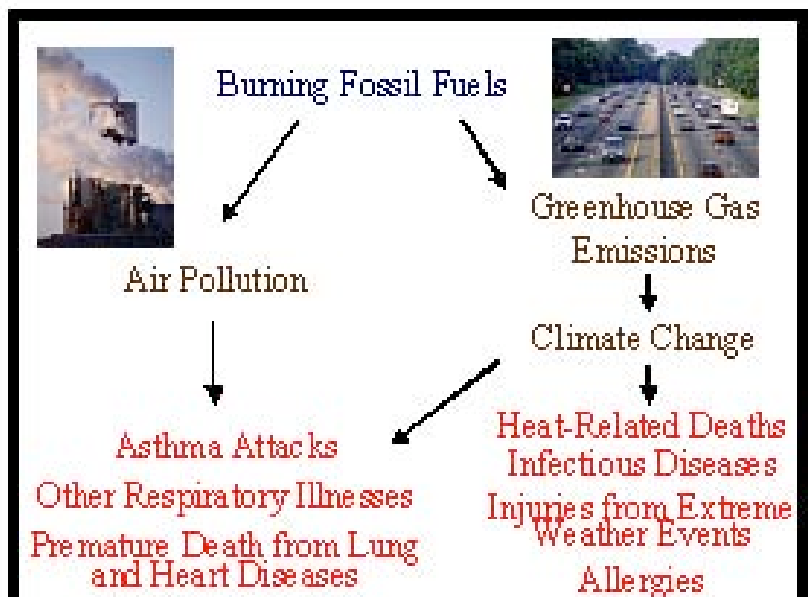
Pollen also provides a vector for diesel particulates to be deposited deep into air sacs in the lungs.

Changes in rates and frequency of precipitation could also support new habitats for pests and pathogens. Wetter environments can cause increased fungal growth in indoor environments, and cycles of drought followed by flooding could aid mosquito propagation and subsequent disease transfers. Floods could also drive rodents from their natural burrows into developed areas.

Extreme weather events would lead to property damage as well as personal injury and trauma. Warmer temperatures could increase the amount of freezing rain and ice storms in winter, leading to driving and pedestrian hazards. Flooding events could increase water-borne illnesses, and heat waves could implicate greater food-borne illnesses.

The myriad of connections between weather and public health pose tremendous opportunity for surprise impacts from rapid and unpredictable climatic changes. The potential costs are great, and many of the predicted consequences, from more frequent heat waves to the appearance of mosquito-borne infectious diseases like West Nile virus, will disproportionately affect our most vulnerable citizens — the poor, the sick, and the elderly.

*See: Indicators of Public Health Impacts from Climate Change for more scientific background and Appendix A: Slide Presentation on Health Impacts of Climate change.*



## CURRENT WORK AT LOCAL HEALTH DEPARTMENTS

After outlining the scientific basis for a public health response to climate change, participants discussed ways in which their programs were already addressing, or would be well suited to address climate change.

For many health directors, this forum marked the first occasion that their agency had considered the issue. Nevertheless, every participant found that their existing programs were already incorporating



Health directors from New York, Atlanta, Portland, and Houston share experiences.

climate change interventions. Cardiovascular health programs were encouraging walking and biking, instead of driving. Health officials were responding to heat emergencies, and educating the public about protection and detection of heat stress. Departments were also monitoring communicable diseases, and were involved with extensive vector-borne disease educational campaigns as a result of the West Nile virus outbreak.

Participants felt that health directors needed to make a deliberate effort to identify these and other linkages between climate change work and their existing programs and policies. Examining current agency structures and identifying where efforts intersected could help to effectively integrate climate change intervention strategies as part of administrative and policy decisions, as well as programmatic work.

Participants shared examples of how they were starting to integrate climate protection work into their organizations. Many of the initiatives had a home in air quality programs, as components of asthma prevention or cardiovascular disease

## ICLEI and CCP campaign

Cities for Climate Protection is a global campaign of the International Council for Local Environmental Initiatives (ICLEI). More than 500 local governments worldwide participate in the Campaign, including over 130 cities and counties in the United States.

ICLEI's Cities for Climate Protection Campaign (CCP) offers technical assistance, training, publications and marketing tools to support the implementation of programs and policies which improve energy efficiency and result in greenhouse gas emissions reductions in all sectors: buildings, manufacturing and industrial facilities, municipal fleets, waste management, land-use planning, renewable energy applications, transportation, and local government operations. {See Appendix D: *Municipal Climate Protection Measures for an expanded list of potential greenhouse gas reduction measures.*}

To participate in CCP, local governments pass a resolution and undertake the following five tasks or milestones:

- A **baseline emissions analysis** of the sources and quantity of greenhouse gas, along with a forecast of emissions growth over 10 to 20 years
- An **emissions reduction target** chosen and adopted locally
- A **local action plan** outlining the activities that will be pursued to achieve the emissions reduction target over a period of years
- **Implementation** of emissions reduction policies
- **Monitoring** progress of measures to reduce greenhouse gases

programs, or as part of regulatory responsibilities. In some cases, public health departments had a great deal of decision-making power, and could set emissions standards for automobiles and power plants. Other agencies depended on collaborative structures to accomplish air quality efforts, such as participating on regional planning task forces or advocating for state legislative initiatives. Smaller scale efforts included anti-idling campaigns, neighborhood air quality monitoring projects, and clean vehicle demonstrations.

Local health departments were also pursuing a great variety of energy efficiency and clean energy measures. One health department was committed to building their new office according to the U.S. Green Building Council standards. Another health department was actively involved with plans to develop a local light rail system. A number of health departments were working with other city agencies to reduce the size and fuel consumption of municipal fleets.

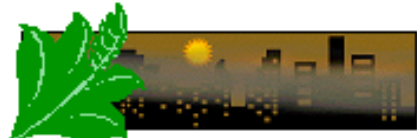
Many of the cities represented were members of the Cities for Climate Protection Campaign (CCP) (see inset on Page 8). While some health officials were unaware of their municipality's involvement, other forum participants were actively engaged in this citywide strategic planning effort. The CCP model serves as a guide for municipal governments to begin a community-wide dialogue on the issue, and to develop a comprehensive package of measures as part of a published action plan. Health departments were, in rare cases, the lead agency for their local CCP, while most others contributed by implementing projects at their facilities, providing general support for the initiative, and educating community members about efficient lifestyle choices.

Health departments were also involved with regional U.S. Department of Energy programs such as Clean Cities, focused on alternative fuel transportation, and Rebuild America, targeted at building retrofits.

## CLIMATE – PUBLIC HEALTH FRAMEWORK DEVELOPMENT

In preparation for the forum, BPHC worked with the facilitator to develop a framework for the discussion. The result, a matrix outlining strategies and impact areas of climate protection interventions (see box below and Appendix E), provided structure to the dialogue. It did not, however, capture the full range of analytical pathways that public health professionals may use to assimilate the climate change issue. Identifying how the issue should fit into the public health discipline was challenging. It was unclear how city health directors should begin to consider climate systems, health impacts, and related interventions. The lack of a uniform and widely understood public health framework for climate change pervaded the forum discussion. Participants felt that, in one way or another, the absence of an existing public health framework hindered work on the issue.

Participants decided that it was of utmost importance to establish a common message on climate change in the public health community. The forum was a first step, but much work needed to be done internally at local health departments and on the national level to mainstream the issue of climate change. Some participants expressed concern that the issue had simply never been discussed at their health department. They felt that there was very little awareness in the public health field about the links between climate change and human health, and that media and scientific literature needed to communicate the issue in a way that resonated with public health professionals.

| <div>  <div> <h3>Climate Change Interventions</h3> <h4>IMPACT AREAS</h4> </div>  </div> |                                                                                                          |                                                                                      |                                                           |                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------|--------------------|
| INTERVENTION STRATEGIES                                                                                                                                                                                                                                       | Transportation<br>Municipal Fleet, Personal Vehicles, Community Traffic, Public Transit, Biking, Walking | Building Energy Use<br>Health Dept., Municipal, Residential, and Commercial Property | Energy Sources<br>Power Plants and Distributed Generation | Other Impact Areas |
| <b>Surveillance and Monitoring</b> <ul style="list-style-type: none"> <li>■ Sentinel diseases (respiratory, etc.)</li> <li>■ Infectious disease</li> <li>■ Heat Stress</li> <li>■ Weather-related injury</li> <li>■ Greenhouse gas emissions</li> </ul>       |                                                                                                          |                                                                                      |                                                           |                    |
| <b>Education &amp; Advocacy</b> <ul style="list-style-type: none"> <li>■ Community Mobilization</li> <li>■ Government/Community/ Public/Private partnerships</li> <li>■ Infrastructure</li> <li>■ Trainings</li> <li>■ Media</li> </ul>                       |                                                                                                          |                                                                                      |                                                           |                    |
| <b>Policy</b> <ul style="list-style-type: none"> <li>■ Economic</li> <li>■ Public Safety</li> <li>■ Conservation</li> <li>■ Public Health</li> </ul>                                                                                                          |                                                                                                          |                                                                                      |                                                           |                    |



Participants from Washington D.C., U.S. EPA, Seattle, and the Massachusetts Executive Office of Environmental Affairs discuss ways to frame the issue of climate change.

In spite of these challenges, there was a strong sense that the public health sector, especially local health departments, could provide valuable leadership in mobilizing the public to recognize and respond to the issue of climate change. At present, the public does not perceive a sense of urgency. The climate change issue is missing a critical element — an emotional content that leads people to act. Health directors felt that communicating the issue as a public health emergency — through analogies to other health events communities were facing such as asthma, bioterrorism, and West Nile — could be helpful. The potential health threats that climate change poses may resonate with people in a way that other messages have not. If health officials, communications officers, and community initiatives staff were to learn a few sound bytes on climate change, they could begin to refer to the issue in their conversations with the community. Some participants recommended developing a Frequently Asked Questions document that would outline the links between health, weather events, and overall climate change. Meteorologists could also be brought into the effort. In this way, the issue could slowly become integrated into the public's understanding of related weather events. For example, heat events could become opportunities to

educate and prepare the public for future warming, as well as to encourage purchases of energy-efficient air conditioners and fans.

Forum participants had the following recommendations for communicating the issue to the community:

- Highlight the economic costs of climate change and the economic benefits of energy efficiency and clean energy technologies. The public may have fears about economic impacts from environmental policy changes.
- Focus on the multiple air quality benefits — NO<sub>x</sub> and VOCs tend to decrease when CO<sub>2</sub> reductions are made — but be wary when they don't compliment each other e.g. diesel fuels emit low levels of greenhouse gas emissions, but high levels of particulate matter.
- Look for teachable moments. Tie the climate message into communications about West Nile, heat waves, outdoor air pollution, etc.
- Don't forget the larger picture: fossil fuels, especially oil, through exploration, extraction, transportation, and combustion, leads to acid rain, air pollution, climate change and real issues of environmental and international justice.

Participants also stressed the need for the public health threats from climate change to be integrated into the web of decision-making formulas at city and regional transportation and energy-related agencies, through formal comments on policy proposals and direct participation from health officials. City health directors must also advocate for public health-climate research and use national agencies as channels for education.

## SURVEILLANCE AND MONITORING

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Participants felt strongly that local health indicators of climate change needed to be widely monitored. They felt that the risks associated with climate change must be better quantified, and that gaps in resource and information allocation should be identified and resolved. There seemed to be a lack of connection between the type of research conducted, and what information the public health community needs to act e.g. well-established causal relationships. Improved research would serve to garner support for addressing the issue of climate change, and help in educating public health professionals on the best strategies to respond to health risks. Some of the strategies identified to further monitoring and surveillance efforts included:

- Identifying a set of sentinel public health indicators and using them to monitor local effects of global climate change.
  - Requesting funding for local monitoring and data collection, as a new research program or as part of pre-existing programs (West Nile virus, bioterrorism).
  - Advocating for sentinel indicators to be incorporated into national research priorities of
- 
- Allergies
  - West Nile and other emerging animal/insect borne disease, malaria
  - Asthma
  - Air quality
  - Water quality and quantity
  - Food borne illness (esp. seafood)

leading public health agencies (CDC, NIH, APHA, NACCHO).

- Strengthening lines of communications between existing researchers and public health professionals.
- Ensuring that research is relevant to local work.

Participants noted that local health departments are well suited to pilot surveillance and monitoring projects, with their strong roots to community and experience in performing field level research. One model discussed at the forum was to distribute palm pilots and digital cameras to community activists who could provide GIS mapping and records of climate change indicators. This strategy was successfully used to identify trash violations, rodents, potholes, vandalism, and broken lights in urban neighborhoods.

Another way that cities could begin to monitor the issue would be to track the source of climate change, greenhouse gas emissions. ICLEI has software to assist municipalities with this task. The software will soon quantify criteria air pollution, in addition to greenhouse gas emissions from energy use, waste management, and open space planning.

- Unusual weather events
- Heat
- Flooding
- Drought
- Heavy Rains

## CONCLUSIONS, RECOMMENDATIONS, AND NEXT STEPS

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Health Directors from Seattle, Los Angeles and New Orleans.

By the end of the forum, participants felt that they had made great progress in beginning to address some of the barriers to climate change work at local health departments. Already, participants felt they had a common and clear understanding of the scientific foundations of climate change, and the causal links to health. They had iterated the need for this common understanding to reach all public health professionals and to begin to translate the issue into a public health threat that the community could grasp. With this base framework, participants felt that city health departments could go far to address the issue through preventative measures, and monitoring and surveillance work.

### Resources

There are a host of resources available for local climate protection work, as well as opportunities for local health departments to form partnerships with likeminded organizations. These resources include:

#### **Dedicated State and Federal Initiatives**

- State climate programs - 40 states have Climate Action Plans
- U.S. EPA energy initiatives and climate change studies
- Climate's Long-Term Impact on Metro Boston (CLIMB)
- EnergyStar
- U.S. DOE
  - Clean Cities Coalitions, Rebuild America programs
  - Technical Assistance
  - Financial resources

- Willing to help connect public health professionals to other energy decision makers

**Academic Institutions:** Schools of public health, engineering, environmental studies, public service

#### **ICLEI**

- New England Network of communities focused on energy and climate change through ICLEI.
- Have ICLEI facilitate collaboration between health departments and CCP lead agencies locally and at national conferences.

#### **Private interests**

- Insurers, developers, real estate

#### **Religious groups**

- National Religious Partnership for the Environment
- Interfaith Power and Light

#### **National visibility**

Addressing climate change will require a great deal of policy change on the national level, as well as an organized dissemination of information and tools to local agencies across the country. Federal agencies and national consortia must identify climate change as a public health priority, and provide directives and support for local agencies and the public as a whole. Many of the forum participants have leadership roles at national public health organizations, and are committed to putting the issue of climate change, and related research needs and mitigation strategies on the tables of these organizations. The group agreed to begin contacting leaders at federal agencies and national consortia to build support for addressing climate change.

#### **Key Public Health Organizations**

Centers for Disease Control and Prevention  
World Health Organization  
American Public Health Association  
National Association of County and City Health Officials  
Association of State and Territorial Health Officials  
State-level Associations

Some of the requests that municipal health officials could make of these organizations, include: Advocating for disclosures of CO2 emissions, like other harmful pollutants.

- Integrating climate change into research priorities.
- Developing materials and workshops to educate public health professionals.

As follow up to this meeting, a letter was sent to the Director of the Centers for Disease Control.

### **Research**

Local health departments must work with national organizations and federal agencies to outline and implement a system to monitor the sentinel climate-related health indicators.

As a follow up to this meeting, Dr. Paul Epstein developed a white paper on indicators. See Background paper below.

### **Communication and Coordination**

The forum participants were committed to continuing the dialogue. Key recommendations included:

- Disseminating this report and building the network of municipal health officials and like-minded organizations.
- Developing an educational website resource for public health professionals.
- Modeling good energy policies and sharing best practices.
- Keeping an eye out for opportunities to collaborate on mitigation measures, such as aggregating hospitals and health departments to buy green power.

# BACKGROUND PAPER: INDICATORS: MONITORING THE HUMAN HEALTH IMPACTS OF CLIMATE CHANGE AND SHIFTING WEATHER PATTERNS FOCUS ON URBAN AREAS

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Prepared by: Paul R. Epstein, M.D., M.P.H.

## INTRODUCTION

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The U.S. National Assessment of the Impacts of Climate Change and Variability (<http://www.usgcrp.gov/usgcrp/nacc/default.htm>) projects that there will be changes in the climate and in weather patterns in every region of the United States in coming decades as a result of increasing atmospheric concentrations of greenhouse gases. These predictions are in keeping with those of the U.N. Intergovernmental Panel on Climate Change for the planet as a whole (Houghton *et al.*, [IPCC] 2001). Changes will involve warming temperatures -- with the largest increases occurring at higher altitudes and latitudes, and during the winter and at night. The warming is also associated with an increase in extreme weather events, with heavy rains (>2"/day) and flooding in some areas and prolonged drought in others.

Accompanying the warming and anomalous weather, major impacts on urban infrastructure are projected, as well as impacts on terrestrial and marine ecosystems; affecting wildlife, forests, agriculture and human health. This brief summary will outline the potential health impacts of climate

change and variability and will discuss in more detail three case studies in the U.S. that provide useful models for understanding the relationship of human health to climate and weather.

The following categories of diseases and other health impacts may be affected by climatic conditions and weather. While each one (e.g., heatwaves or emerging infectious diseases) can occur in the absence of climate change, it is projected that climate change and the associated alterations in weather patterns will influence the frequency, intensity and geographic distribution of these health outcomes. Understanding the health/climate/weather connections can

- a) Help generate early warning systems for environmentally-friendly public health interventions; and
- b) Help monitor and understand the short and long-term health consequences of climate change and the associated changes in weather patterns.

## AREAS COVERED

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- Heat stroke, dehydration, heat exhaustion and heat waves
- Cardio-respiratory disease and air quality
- Emerging infectious diseases (EIDs) and climate warming and variability
- Traumatic injuries and extreme weather
- Gastro-intestinal infections and water quality

Additional issues include: morbidity and mortality associated with weather-related impacts on food quality, especially seafood, and the health impacts of sea level rise and storm surges (e.g., from flooding, salt water intrusion of well water, etc.).

## HEATWAVES

Recent record-high temperatures in many parts of the United States highlight the need for an awareness of the health hazards posed by global warming. Heat waves can cause dramatic increases in overall morbidity and mortality, and they have increased the number of deaths per day 2 to 3-fold over baseline levels in particularly severe episodes

<http://www.cdc.gov/mmwr/preview/mmwrhtml/0000041.htm>.

From 1979 –1999, excessive heat exposure caused 8,015 deaths in the United States. During this period, more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined (<http://www.cdc.gov/nceh/hsb/extremeheat/>). The incidence of heat waves in most U.S. cities is expected to approximately double by the year 2050 by current climate change estimates (Kalkstein, 2000).

The health impacts of heatwaves are a function of average temperatures, nighttime temperatures (minimum), and the heat index (which is a measure of humidity and temperature combined, where high humidity levels interfere with the human body's ability to cool itself by transferring heat, through radiation and evaporation, to its surroundings). Minimum nighttime temperatures have been rising twice as fast as overall warming since 1950 (Karl et al., 1993; Easterling et al., 1997), which is predicted by climate change models. The “heat island effect,” where the heat generated by the cumulative activities of concentrated populations increases the ambient temperature 5-10 degrees F. above that of surrounding, less urban areas, is present in most U.S. urban centers and adds to the intensity of heatwaves. It is, in turn, affected by the presence of urban trees and parks, roof gardens, and heat reflective building colors, particularly on rooftops.

### Case Study: The 1995 Chicago Heatwave

The Chicago heatwave in the summer of 1995 well illustrates how heat waves influenced by climate change will affect human populations. In this case, there was the lethal combination of high humidity and unusually high nighttime temperatures, so that Chicago residents had little relief at night (CDC, 1995; Whitman et al., 1997). During July 12-16, 1995, Chicago experienced unusually high maximum daily temperatures, ranging from 93 F to 104 F (33.9 C to 40.0 C). On July 13, the heat index peaked at 119 F (48.3 C) -- a record high for the city.

During July 11-27 the Cook County Medical Examiner's Office (CCMEO) certified 465 as heat-related, compared with no heat-related deaths during the period of July 4-10. The highest number of heat-related deaths previously certified by the CCMEO was 77 in association with a heat wave in the summer of 1988. During July 13-21 (the period with the most heat-related deaths), a total of 1177 deaths occurred in Chicago -- an 85% increase over the same period in 1994 (637 deaths). A subsequent analysis demonstrated that there were at least 700 excess deaths in Chicago during the heat wave, most of which were heat-related (Semenza et al, 1996). And recent reports have confirmed that there were long-term neurological effects among some of those who had heat stroke but survived (reference to be obtained).

Those at greatest risk of dying from the heat wave were people with chronic medical illnesses. But socioeconomic factors were involved as well; poor and socially isolated people without access to air conditioning were disproportionately affected. Early warning systems are now in place in some U.S. cities (Kalkstein, 2000) and Canada (Smoyer-Tomic *et al.*, 2001), with a program to identify those who live alone, particularly those who are chronically ill medically or psychiatrically. Effective measures for preventing heat-related illness and death include reducing physical activity, drinking nonalcoholic liquids, and spending time in air-conditioned environments.

Severe summer heatwaves, with numerous attributable deaths, have become increasingly common in developing nations as well, notably New Delhi, India.

## CARDIO-RESPIRATORY DISEASE AND AIR QUALITY

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The following are examples of how climate change can affect cardio-respiratory disease:

**Pollen**--pollen release from ragweed and some trees (e.g. birches and poplars) is increased by higher levels of atmospheric CO<sub>2</sub> (in the case of ragweed, with a doubled CO<sub>2</sub> concentration, 60% more pollen is released) (Wayne *et al.*, 2002). Warm winters and the early arrival of spring may exacerbate this effect. Increased pollen levels may explain some of the increased incidence of asthma and respiratory allergies.

**Ground-level ozone or photochemical smog**--the reaction of oxides of nitrogen (NO<sub>x</sub>s) and volatile organic compounds (VOCs) [both tailpipe emissions] is temperature-dependant; i.e., heat increases smog. Ground-level ozone, which is also increased by higher levels of ultraviolet B radiation from stratospheric ozone depletion, has been shown to cause asthma in children and to trigger attacks (McConnell *et al.*, 2002). Photochemical smog also causes increased morbidity and mortality in those with chronic obstructive pulmonary disease.

**Diesel exhaust particulates** (a direct air pollutant from burning fossil fuels) —these particles cause significant illness, especially when they are smaller than 10 microns in diameter and can bypass the lung's defenses. They can:

1. Clog airways and cause acute, and worsen chronic, cardiovascular and respiratory illness;
2. Help deliver pollen grains and molds deep into the lung;
3. Cause lung cancer.



Ragweed

**Heatwaves** can result in temperature inversions, leading to trapped masses of unhealthy air contaminated by smog, particulates, and other pollutants.

**Fires**—the incidence of forest fires is increased by drought secondary to climate change, and to the lack of spring runoff from reduced winter snows. These fires create smoke and haze which can settle over urban populations causing acute and exacerbating chronic respiratory illness (e.g., the Heyman fire in Colorado, summer 2002). The extensive, severe forest fires in Indonesia in 1997/98 were the result of small fires, started to clear the forests for agriculture, which quickly became out of control due to a severe drought. The resulting plume of smoke settled as haze over large down-wind populations in Southeast Asia, causing widespread respiratory illness.

## EMERGING INFECTIOUS DISEASES

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Since 1976, the World Health Organization reports there are 30 infectious diseases that are new to medicine. These include Ebola, Legionella, Lyme disease, Hantavirus Pulmonary Syndrome, a new strain of cholera (*Vibrio cholerae* O139), *E. coli* O157:H7, HIV/AIDS, and a host of antibiotic-resistant organisms. In addition, there is a resurgence of some old diseases (malaria, dengue fever, cholera), and a redistribution of others (e.g., West Nile virus) occurring on a global scale. Many emerging diseases are zoonoses, or animal diseases, that spill over to humans, and are responsive to environmental change and climatic variability. For example, “explosions” of rodent populations can follow droughts punctuated by heavy rains, because such weather patterns can result in a decreased population of rodent predators and an increased supply of food (this was the case, for example, with the outbreak of Hantavirus Pulmonary Syndrome in the four corners area of New Mexico in 1993).

Moreover, climate (especially winter [minimum] temperatures) can restrict the geographic range of some infectious diseases by altitude and by latitude (in the case of vector-borne infectious diseases, for example, by being too cold above a certain altitude or latitude for a vector, host, or infectious agent to survive) (Epstein et al., 1998), while weather can affect the timing, intensity, and location of outbreaks. Rising minimum (winter) temperatures are particularly important in allowing the overwintering of some diseases vectors (e.g., ticks or mosquitoes), and in increasing the number of reproductive generations (e.g., rodents). In addition, extreme weather events (especially droughts and floods) often precipitate clusters of rodent-, mosquito- and water-borne diseases (Epstein, 1999).

### Case Study—West Nile Virus

West Nile virus (WNV) was first reported in Uganda in 1937. WNV is a zoonosis, with “spillover” to humans, which also poses significant risks for wildlife, zoo and domestic animal populations. While it is not known how West Nile virus (WNV) entered the New World in 1999, anomalous weather conditions may have helped amplify this *Flavivirus* that circulates among urban mosquitoes, birds and mammals. Analysis of weather patterns coincident with a series of U.S.

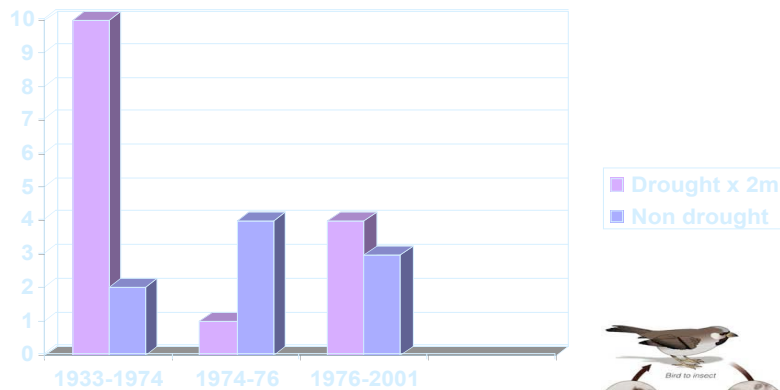
urban outbreaks of St. Louis encephalitis (SLE), (a disease with a similar life cycle), and four recent large outbreaks of WNV, revealed that drought was a common feature. *Culex pipiens*, the primary mosquito vector (carrier) for WN, thrives in city storm drains and catch basins, especially in the organically rich water that forms during drought and the accompanying warm temperatures. As the potential risks from pesticides for disease control must be weighed against the health risks of the disease, an early warning system of conditions conducive to amplification of the enzootic cycle could help initiate timely preventive measures, and potentially limit chemical interventions

### Background on WNV

West Nile virus, first reported in Uganda in 1937, entered the Western Hemisphere in 1999, most likely via migratory or imported birds from Europe. But, while the precise means of introduction is not known, experience with a similar virus -- St. Louis encephalitis (SLE) -- as well as the European outbreaks of WNV during the 1990s -- suggests that certain climatic conditions are conducive to outbreaks of this disease. Evidence suggests that mild winters, coupled with prolonged droughts and heat waves, are the conditions that amplify these two diseases that cycle among urban mosquitoes (*Culex pipiens*), birds and humans.

SLE and WNV are transmitted by mosquitoes to birds and other animals, with occasional “spillover” to humans. *Culex pipiens* typically breed in organically rich standing water in city drains and catch basins (as well as unused pools and tires). During a drought, those pools become even richer in the organic material that *Culex spp.* needs to thrive. Excessive rainfall flushes the drains and dilutes the pools. Drought conditions may also lead to a decline in the number of mosquito predators, such as amphibians and dragonflies, and encourage birds to congregate around shrinking water sites -- where the virus can circulate more easily. In addition, high temperatures accelerate the extrinsic incubation period (period of maturation) of viruses (and parasites) within mosquito carriers. Thus higher temperatures enhance the potential for transmission and dissemination. Together these factors increase the possibility that infectious virus

## ST. LOUIS ENCEPHALITIS 1933-2001



levels will build up in birds and mosquitoes living in close proximity to human beings.

### Outbreaks of St. Louis encephalitis in the U.S.

SLE first emerged in the city of St. Louis in 1933, during the dust bowl era. Since 1933 there have been 24 urban outbreaks of SLE in the US. SLE as an appropriate surrogate for study because of its similarity to WNV, and because of the significant number of SLE outbreaks in the U.S. along with accurate weather data. For the US outbreaks we examined meteorological data, using the Palmer Severity Drought Index (PSDI); a measure of dryness that is a function of precipitation and soil moisture compared with 30 years of data in the same location. The PSDI ranges from -4 (dry) to +4 (wet) -- (National Climatic Data Center, National Oceanographic and Atmospheric Administration, U.S. Dept of Commerce, ([www.ncdc.noaa.gov](http://www.ncdc.noaa.gov))). The examination revealed that from 1933 to the mid-1970s 10 of the 12 urban SLE outbreaks -- regionally clustered in Kentucky, Colorado, Texas, Indiana, Tennessee and Illinois -- were associated with 2 months of drought (one of the other 2 with one month of drought). After the mid-1970s the relationship shifts and outbreaks are associated with anomalous conditions that include droughts and heavy rains.

Note: Outbreaks of SLE during the 1974-76 period and after show a variable pattern in relation to weather (occurring with drought or, alternatively, after anomalous rains). Once

established in a region, summer rains may boost populations of *Aedes japonicus* and other *Aedes spp.* that can function as “bridge vectors,” efficiently carrying virus from birds to humans. The roles of “maintenance” (primarily bird-biting mosquitoes) and bridge vectors in WNV transmission are under study.

### Significant outbreaks of WNV in the past decade



**Romania 1996:** A significant European outbreak of WNV occurred in 1996 in Romania, in the Danube Valley and in Bucharest. This episode, with hundreds experiencing neurological disease and 17 fatalities, occurred between July and

October and coincided with a prolonged drought (May through October) and excessive heat (May through July). Human cases in Bucharest were concentrated in blockhouses situated over an aging sewage system where *C. pipiens* were breeding in abundance.

**Russia 1999:** A third large outbreak of WNV occurred in Russia in the summer of 1999, following a drought. Hospitals in the Volgograd Region admitted 826 patients; 84 with meningoencephalitis, of which 40 died.

**Israel 2000:** WNV was first reported in Israel in 1951, and sporadic outbreaks followed. Israel, a major stopover for migrating birds, usually receives little precipitation from May to October. In 2000, the region was especially dry, as drought conditions prevailed across southern Europe and the Middle East, from Spain to Afghanistan. Between August 1 and October 31, 2000, 417 cases of serologically confirmed WNV were diagnosed in Israel with 35 deaths. *C. pipiens* was identified as a vector.

**US 1999:** In the spring and summer of 1999, a severe drought (following a mild winter), affected the Northeastern and Mid-Atlantic States. The prolonged drought culminated in a three-week July heat wave that enveloped the Northeast. Then the pendulum swung in the opposite direction, bringing torrential end-of-August rains (and, later, Hurricane Floyd to the Mid-Atlantic States). *Culex spp.* thrived in the drought months; *Aedes spp.* bred in the late summer floodwaters. In the NY outbreak

seven people died and of the 62 people who suffered neurological symptoms and survived, most report chronic disabilities, such as extreme muscle weakness and fatigue.

**US 2002:** In the summer of 2002 much of the West and Midwest of the U.S. experienced severe spring and summer drought. Lack of snowpack in the Rockies (warming winters leading to more winter precipitation falling as rain) contributed. Forest fires burned over 7.3 million acres, and haze and respiratory disease affected several Colorado cities. There was also an explosion of WNV cases (see chart below), with humans or animal WNV being documented in 43 states and the District of Columbia, reaching to California. Drought conditions were present in June in Louisiana in June, the first epicenter of WNV in 2002. Widespread drought conditions and heatwaves may have amplified WNV and contributed to its rapid spread throughout the continental U.S. (Health officials have also become convinced that WNV can be transmitted via organ transplant and blood transfusion.)

Of greatest concern, however, WNV has spread to 230 species of animals, including 138 species of birds and 37 species of mosquitoes. Not all animals fall ill from WNV, but the list of hosts and reservoirs includes: dogs, cats, squirrels, bats, chipmunks, skunks, rabbits and reptiles. Raptors (owls, kestrels) have been particularly affected; West Nile virus likely caused thousands of birds of prey to die in Ohio and other states in July 2002. Some zoo animals have died (e.g., 8 Humboldt penguins in the Milwaukee Zoo and macaques.)

**Note:** The population impacts on wildlife and biodiversity have not been adequately evaluated. The impacts of declines in birds of prey could ripple through ecological systems and food chains, and

could in itself contribute to the emergence of disease.

Declines in raptors – condors, owls, hawks, eagles, kestrels and marlins – could have dramatic consequences for human health. (Some raptors have died, but the population-level impacts are as yet unknown.) These birds of prey are our guardians for they prey upon wayward rodents and keep their numbers in check. When rodent populations “explode” – when floods follow droughts, forests are clear-cut, or diseases attack predators – their legions can become prolific transporters of pests and pathogens, including: Lyme disease, leptospirosis and plague, hantaviruses and arenaviruses – like Lassa fever, Guaranito, Junin, Machupo and Sabia viruses, associated with severe hemorrhagic fevers in humans.

As of March 12, 2003, the Centers for Disease Control and Prevention (CDC) reported:

|                         |       |
|-------------------------|-------|
| Laboratory confirmed    |       |
| human cases nationally: | 4,156 |
| WNV-related deaths:     | 284   |

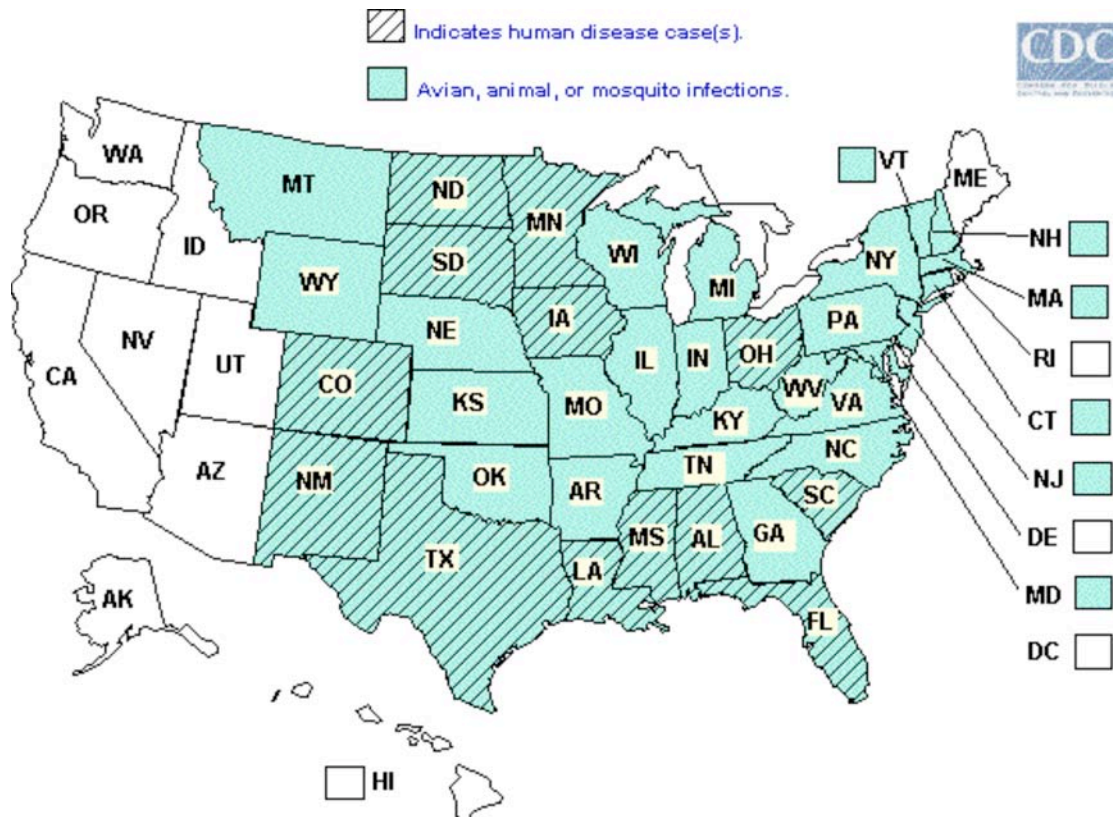
Most deaths: Illinois (64), Michigan (51), Ohio (31), Louisiana (25).

**Equine cases** were 14,045 in 38 states, reported to USDA APHIS by state health officials as of 26 Nov 2002. WNV has now been associated with illness and death in several other mammal species, including squirrel, wolf, and dog in Illinois,, and mountain goat and sheep in

Most equine cases: Nebraska

Moreover, because of the bird and mammal reservoirs for WNV, there is the potential for outbreaks in all Eastern and Gulf States of the US and into Canada in the coming years.

## West Nile Virus in the United States as of August 1, 2003



### Conclusions and Discussion:

Multi-month drought, especially in spring and early summer, was found to be associated with urban SLE outbreaks from its initial appearance in 1933 through 1973 and with recent severe urban outbreaks of WNV in Europe and the U.S. Other factors, such as inadequate sanitation, sluggish urban waterways and abandoned tires, may increase vulnerability to urban arbovirus outbreaks. Each new outbreak requires introduction or reintroduction of the virus, primarily via birds or wildlife – so there have been seasons without SLE outbreaks despite multi-month drought. Spread of WNV and sporadic cases may occur, even in the absence of conditions amplifying the enzootic cycling. In Bayesian parlance, drought increases the “prior probability” of a significant outbreak once

the virus becomes established in a region, other factors, such as rains that increase populations of bridge vectors, may affect transmission dynamics.

Further investigation and modeling are needed to determine the role of meteorological factors, and identify reservoirs, overwintering patterns, and the susceptibility of different species associated with WNV. The migration path of many eastern U.S. birds extends from Canada across the Gulf of Mexico to South America

(<http://www.npwrc.usgs.gov/resource/othrdata/migratio/prince.htm>).

### Public Health Implications

Factors other than weather and climate contribute to outbreaks of these two diseases disease. Antiquated urban drainage systems

leave more fetid pools in which mosquitoes can breed, and stagnant rivers and streams do not adequately support healthy fish populations that consume mosquito larvae in isolated standing pools. Such environmental "vulnerabilities" present opportunities for environmentally based public health interventions following early warnings of conducive meteorological conditions.

State plans to prevent the spread and contain WNV have three components:

Mosquito and dead bird surveillance.

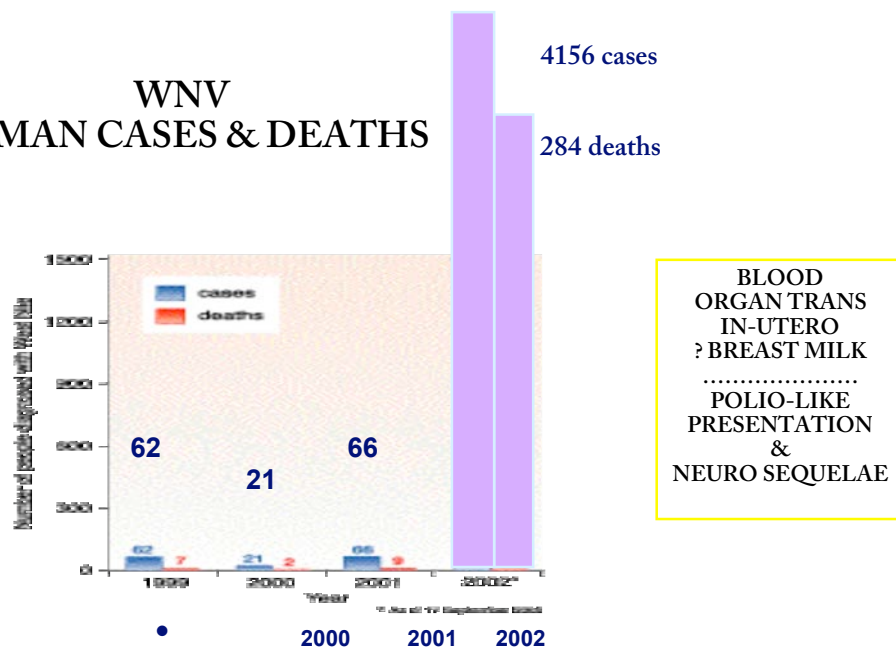
Community communications and media outreach;

Source (breeding site) reduction though larviciding with bacteria (*Bacillus sphaericus*) and Altocid (methoprine) and neighborhood clean-ups; and Pesticide (pyrethrins, synthetically derived from chrysanthemums) spraying, when deemed necessary.

The information on predisposing climatic conditions and predictions of them may be most applicable for areas that have not yet experienced WNV, but lie in the flyway from Canada to the Gulf of Mexico. Projections of droughts (e.g., for Northeast Brazil during an El Niño event) could help focus attention on those areas, enhancing surveillance efforts (including active bird surveillance), public communication and environmentally-friendly, public health interventions. They may also help to set the stage for earlier chemical interventions once circulating virus is detected.

Finally, in terms of the public perception and concerns over the risks of chemical interventions: understanding the links of WNV to climatic factors and mobilizing public agency departments, such as water and sewage services, to address a public health threat may prove helpful in garnering public support for the combined set of activities needed to protect public health.

## WNV HUMAN CASES & DEATHS



*Science* 2002;297:1988 (updated)

## TRAUMATIC INJURIES AND EXTREME WEATHER EVENTS

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Anomalous weather and extreme events have increased in intensity, and they are projected to increase in frequency, as climate changes (IPCC, 2001). Some events, like heat waves, have already become more common; droughts have become more prolonged, and heavy rain events ( $>2$ "/day) have increased over the past century (Karl *et al.*, 1995; Easterling *et al.*, 2000). Storms can effect populations directly, but they can also do so indirectly, as they can increase the number of breeding sites for disease vectors; and drive nutrients, microorganisms and toxic chemicals into waterways and water supplies, affecting both the food and water supply. Fog, avalanches, ice, wind and hail storms are all potentially affected by changes in ambient temperatures and alteration of the hydrological cycle.

While there continues to be debate about whether greenhouse warming and climate change leads to an increased frequency of severe storms and hurricanes, there is broad consensus that the amount of water dumped by such storms has been increased. There are two reasons for this. With warming, there is both an increased evaporation of

water from land and from the oceans, and an increased capacity of the atmosphere to hold water. As a result, there is increased cloud formation and when it does rain, the rains can be torrential. This has been observed in recent hurricanes in the U.S. (e.g., Hurricane Floyd, drenching the Mid-Atlantic States in September 1999), and in Hurricane Mitch in Central America in November 1998 in Honduras (with six feet or rain over 3 days). The enormous amounts of precipitation have led to massive flooding, mudslides, the wash out of roads and bridges, and the resulting injuries and deaths from drownings, car accidents, and the collapse of homes and other buildings. The freezing rain and ice storms seen in winter are also the result of warming temperatures, leading to driving and pedestrian hazards.

Ice storm traffic deaths and power outages, such as those occurring in December 2002 in Arkansas and North Carolina, are examples of the potential impacts of early storms and anomalous weather.

## GASTRO-INTESTINAL INFECTIONS AND WATER QUALITY

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Water quality and quantity are affected by climate and weather. Some parts of the US are experiencing chronic shortages of precipitation (e.g., the West and Midwest), while others are experiencing an excess (e.g., the Northwest). [Water withdrawals and competing uses are contributing to water problems in many parts of the U.S., and changes in precipitation patterns are exacerbating the issues of shortages in some parts and excess in others.]

### Case Study—the Milwaukee Cryptosporidium Outbreak

In addition, floods are related to water-borne diseases. The torrential rains in 1993 (that led to the flooding of the Mississippi River valley) resulted in the largest waterborne disease outbreak in U.S. history in Milwaukee, Wisconsin. The rains washed a protozoan called *Cryptosporidium* from farm lots (it is present in the stools of livestock) into surface

waters that supply Milwaukee with drinking water. An estimated 403,000 persons contracted *Cryptosporidiosis*, a gastrointestinal infection of varying severity in different populations. This constituted an incidence rate of 52% among all those served by the South Milwaukee water works plant (MacKenzie *et al.*, 1994). In most people exposed, the infection was mild and self-limited and did not cause serious illness. In others, especially in those with compromised immune systems (e.g., those with HIV/AIDS infections or those being given chemotherapy for cancer), the situation was very different. In this group, there were over 100 deaths (Vakill *et al.*, 1996).

An extensive study of water-borne disease outbreaks for the U.S. demonstrates the strong association with heavy rain events and flooding (Curriero *et al.*, 2001) (Also see review of climate and disease: Patz *et al.*, 2001).

## FOOD QUALITY

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Food quality can be affected by heat. Episodes of bacterial food contamination in Japan are highest during the summer, and notable outbreaks have accompanied prolonged summer heatwaves (McMichael *et al.*, 1996).

Seafood contamination with biotoxins (biological toxins) is associated with “red tides,” or harmful

algal blooms (HABs). Excess nutrients and the loss of filtering wetlands, combined with warm, stagnant seas can lead to red tides and outbreaks of shellfish contamination (paralytic, neurological, amnesic and diarrhetic shellfish poisoning). In addition, heavy rains can flush nutrients into estuaries and coastal zones, triggering HABs (Epstein *et al.*, 1998; Harvell *et al.*, 1999).

## SEA LEVEL RISE AND STORM SURGES

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Sea level rise (SLR) presents a longer-term threat to infrastructure and human health. SLR can lead to salinization of underground water, with implications for hypertension and the availability of potable water. SLR can also increase the frequency of storm surges and associated damage to infrastructure and sanitation systems, contamination of ground and surface water with farm animal wastes, and the overflow of Combined Sewer systems.

Climate change and increased variability of weather pose numerous threats to public

health. The issues range from heatwaves, synergies with air pollution, infrastructure damages, and water quality to WNV. Some issues will be most felt in urban settings; others more rural. Monitoring those conditions that are affected by climate and weather can be integrated into the practices of public health departments. Such integration can provide early warnings and guidance for prioritizing interventions and involvement of public health departments in long-range prevention.

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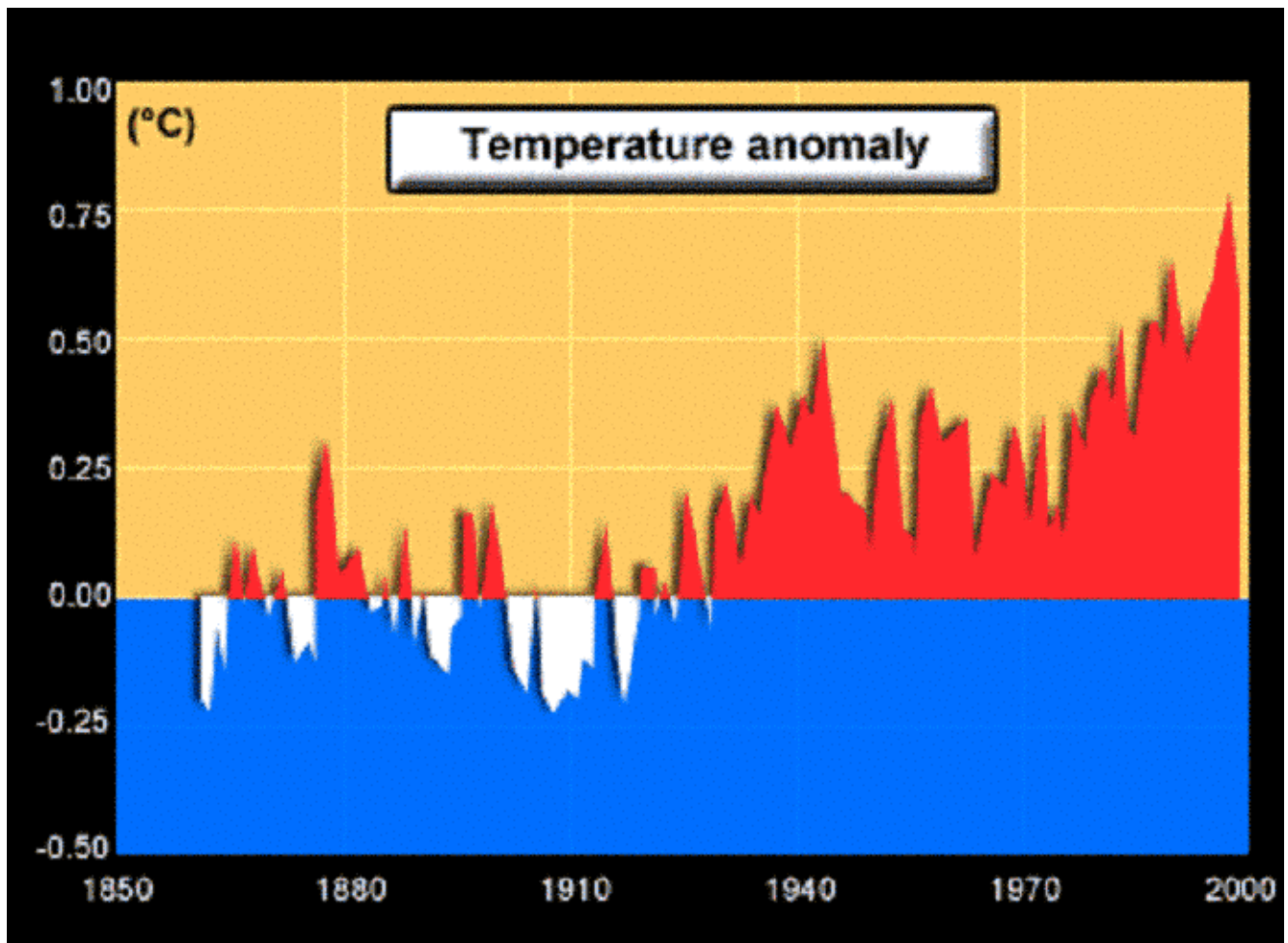
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## Appendix A: Slide Presentation on Health Impacts of Climate Change



# Appendix B: Summary Notes

## Q & A FROM PRESENTATION ON HEALTH IMPACTS OF CLIMATE CHANGE

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Q: What's the relationship between diesel fuel and climate change?

A: While diesel fuel has lower greenhouse gas emissions than gasoline or CNG, increased pollen from climate change can glob onto the diesel particulates. There are drawbacks to every type of fossil fuel and to the combustion engine; a hydrogen economy with fuel cell technology is a clean future. (see book by Jeremy Leggett)

Q: How predictable are temperature and rainfall changes in the southeast U.S.?

A: It is difficult to predict on the short-term. El Niño events, representing a 1-4°C warming in the eastern Pacific, occur every 2-7 years since 1877 (when records began). Since 1976, however, they have occurred more frequently, with greater intensity and longer duration -- perhaps as a result of warming of the deep oceans down to 32 miles. El Niño events are associated with more extreme weather events worldwide, but in a pattern that is somewhat predictable and thus helpful for generating health early warning systems.

According to data from the National Oceanic and Atmospheric Administration, heavy rainfall and rising temperatures are consistent with a trend of wetter, milder weather in the southeast U.S. (For the fall 2002 prediction, see: <http://www.noaanews.noaa.gov/stories/s997.htm>).

Q: Why aren't weather forecasters talking about this issue?

A: The Center for Health and the Global Environment (CHGE) is talking with the American Meteorological Society about integrating climate change into weather forecasts. Daily weather events do not equal climate change. But, weather forecasters should make connections between weather events and larger trends.

Q: Trends on slides show major ups and downs with connecting factors. Interventions, however, are not always based on trends, but on surprise events e.g. West Nile. We really need to think about a variety of indicators, don't we? And we need to be aware that treating West Nile, for example, with a great deal of antibiotics, can lead to other cyclical impacts, for example, an overuse of antibiotics.

A: Yes. It is difficult to deal with an issue of multicausality. Implications of climate trends may be social, ecological, etc. We need to both protect the public from impacts, and prevent them from happening in the first place. Protect and prevent.

Q: We made great strides in ozone abatement to date; how will rising temperatures impact these achievements?

A: According to EPA, there may be a false sense of security in areas that have recently reached attainment of ozone standards. Ozone is sunlight and temperature dependent; much of the U.S. is predicted have hotter summer days, leading to an increase in ozone formation.

## DISCUSSION OF CURRENT ACTIVITIES, UPCOMING ACTIVITIES, AND STRATEGIES ON THE LOCAL LEVEL

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- Municipal Fleet
  - Retrofit vehicles to use CNG or other clean fuels
  - Certify auto emission standards (DC)
  - Purchase hybrid and alternative fuel vehicles
  - Purchase cleanest conventional vehicles
  - Rotate out large, inefficient vehicles and replace with right-sized, efficient cars
  - Reduce # of vehicles in city fleet (Houston)
    - Cars inaccessible to employees who don't use them
    - Teleconferencing and carpooling are encouraged

- Cars have tracking mechanisms to monitor use, location, fuel consumption
  - Transportation Patterns and Community Vehicle Choice
    - Regional collaboration on transport planning. Sit on regional transportation board, assist with emissions and health data, set standards for emissions. (Columbus)
    - Work through ozone commitments – regional planning
    - Support light rail and HOV lanes
    - Downtown revitalization (vs. urban sprawl) leads to better transit access, and walking
    - Programs that promote walking (cardiovascular co-benefits)
    - Anti-idling campaigns and tickets to violators
    - Work with unions to provide transit passes
    - Use municipal clean vehicles as educational tools for personal vehicles
    - Reduce car use and improve public transit (light rail, clean vehicle purchases)
      - “Get out of your car” campaign – prevention focus (Portland)
      - Pay for employee public transit, not parking (Portland)
  - Project CLEAR (Columbus, in collaboration w/ other health departments, OH EPA, OSU, Planning Association)
    - Assess air quality
    - Provide voluntary and regulatory policy recommendations
    - Education
    - Collaboration w/community groups
    - Provided impetus for light rail in Columbus/Franklin county
  - Public Buildings
    - Aggregate hospitals and health departments to buy green power
    - Green buildings
      - New and renovated (Newton, Houston)
      - Energy efficient
        - New buildings have sensors to regulate light and temperature (Portland)
        - Energy consultant hired to work on lights, windows for health dept. (Columbus)
  - Community Buildings
    - Green guidelines, incentives, and/or requirements for new construction
  - ICLEI – monitoring of local GHG emissions and potential cost-savings (Brookline, Cambridge, other CCP cities – see [www.iclei.org/us/ccp](http://www.iclei.org/us/ccp) for more info)
    - Provides footprint
    - PH has not been lead agency in many cities
    - ICLEI provides technical assistance, software
    - Vehicle emissions
    - Building energy use
    - Traffic signals and streetlights
    - Waste disposal
  - Waste Management
    - Recycling programs
      - Recycling tires can also prevent West Nile
  - Develop comprehensive Global Warming Plan, set GHG emissions reduction targets (Portland, Brookline, Cambridge)
    - Reduce small engine use such as leaf blowers (Portland)
    - Support local Office of Sustainability, make sure it doesn't suffer cutbacks (Portland)
    - Change individual attitudes – education
    - LED traffic signals
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## SURVEILLANCE & MONITORING DISCUSSION

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- Need for funding from legislature to monitor health impacts, air quality, emissions.
- Best mechanisms for collection? Chronic disease surveillance, specialized epidemiological/acute surveillance, hospital based data. Strengthen and improve these mechanisms.
- Identify gaps in resource & information allocation.
- Need to draw on data and build evidence. Quantification of risks.
- Indicators
  - West Nile and other emerging animal/insect borne disease, malaria
  - Allergies
  - Asthma – a real bridge to community
  - CO<sub>2</sub>
  - Air quality
  - Energy benchmarks
  - Water quality and quantity
  - Food borne illness (esp. seafood)
  - Unusual weather events
    - Heat
    - Flooding
    - Drought
    - Heavy rain events (>2"/day)
- ICLEI is developing new software that will quantify criteria air pollutants, in addition to GHG.
- Community analysis of environmental quality (NYC)
- Palm pilots & digital cameras distributed to community activists
  - GIS mapping and records of trash, rodents, potholes, vandalism, broken lights
  - Need to translate to climate change sentinels

## EDUCATION AND MOBILIZATION ON THE GOVERNMENT LEVEL

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- Energy decisions tend to be driven by cost, PH needs to be at the table to make sure health concerns are included in decision-making formula e.g. retrofitting city buildings; regional transportation planning table where decisions are made concerning GHG emissions, PM and ozone levels, and land use.
- Local health dept. should also influence state and federal policy, work to get disclosure on CO<sub>2</sub> and other emissions from local and state decision makers. Promote policy requirements for federal funding (like compliance w/emission control). Mandatory policies may also be needed (like HIPPA) – deadlines, mandates, tax credits, emissions regulation.
- Use politics to increase awareness and momentum – think in terms of political and economic expediency; recognize political context, globalization, "homeland security".
- Integrate into public health mission/policies such as Healthy People 2010 vs. individual health, national health goals from CDC and federal level so that funding will support link between disease, health outcomes, social determinants, and environment. Health impact planning w/ the legislature - \$ for monitoring and data collection.
- Address fears of economic impact of environmental policy change (losing jobs, industry influence) by outlining the economic costs of climate change and the economic benefits of energy efficiency and clean energy technologies.
- Work with environment departments to develop
  - Health impact studies
  - Economic perspectives
- Identify cross linkages with agencies at all levels; look at relationships to existing programs.
- Structure of health departments vary – which programs intersect? How can we change things to become more interconnected?
- Need to develop climate change “sound bites” – health literacy for all health providers, especially staff in our PH departments.
- Educate all leaders about climate change from public health point of reference, especially mayors.
- Develop purchasing criteria with positive environmental attributes.
- Government, especially public health agencies, should model responsible policies and projects.
  - ICLEI Cities for Climate Protection networks communities that are modeling clean energy, green bldg solutions.
- EPA/DOE can provide resources, networking, and training.

- Local governments can litigate petrochemical companies or U.S. government– upstream approach

(City of Boulder).

## EDUCATION AND MOBILIZATION AT THE COMMUNITY LEVEL

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- Town meetings where community advocacy groups participate. (Climate Action Brookline)
- Improve community-based literacy; find a way to communicate science-based decision making with community.
- Improve public image of green building. (Portland)
- Work with religious/faith-based organization for environmental advocacy – “greening of theology”
  - “Ethics – the ability to see the consequences of one’s actions”

- Work with schools of public health and American Lung Association.
- Work with programs that have beneficial impacts i.e. walking clubs.
- Empirical relationships between social justice, disparities.
- “Recycle your tires and buy more efficient ones” to prevent WNV.
- Partner with community activists.
- Translate cost-savings into behavior change that benefits health (public transport vs. driving)

## CHALLENGES/BARRIERS

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- No sense of immediacy/urgency – missing an emotional content that leads people to act.
- Lack of authoritative info about health connection. Information not shared between scientific and PH community. There may also be a lack of connection between the type of research conducted, and what information the PH community needs to act – e.g. well-established causal relationships.
- Unclear who should create analytical path and translation.
- Lack of direct authority over critical energy/pollution control mechanisms. Jurisdiction problem – which agency leads?

- PH is sometimes not seen as relevant to transportation planning, purchasing, etc.
- Loss of infrastructure and resources through budget cuts.
- Dependence on fossil fuels and ambivalence in society about acknowledging this dependency. An effective energy policy will amount to “rewiring the world”.
- Fossil fuel industry pressure and misinformation campaign.
- Feedback cycle is overwhelming – heat will lead to a/c use, producing more GHG emissions, leading to more heat events.

## TOOLS TO LINK PUBLIC HEALTH AND CLIMATE CHANGE: MESSAGE MAKING

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- Translation of evidence (etiology), impacts/risk (personal/community health), costs (energy use, health effects) into an urgent public health issue. Tie into people’s emotional/other sense of importance.
- Use public health crisis to teach. Use public health frameworks and analogies. Use experience of violence and other issues making national public health concern.
- Use concern over WNV and asthma to drive home urgency.
- Summertime focus on heat waves – outdoor jobs, preventative measures, average temps are getting higher.

- Develop messages based on FAQs about health and weather events. Help local health officials make connection between weather events, health, and global climate change. Work with meteorologists.
- Get away from “disease of the moment”, start to connect the dots between underlying, long-term concerns like global climate change.
- Don’t forget the larger picture: fossil fuels, esp. oil – exploration, extraction, transportation, combustion – leads to acid rain, air pollution, climate change and real issues of environmental and international justice.
- Develop explicit counter-argument to fossil-fuel industry propaganda.

- Focus on multi-benefits, NO<sub>x</sub> and VOCs tend to decrease when CO<sub>2</sub> reductions are made
  - But, be wary when they don't compliment each other (diesel vehicle PM)
- 78% of Massachusetts residents surveyed believe that climate change is happening; 53% are very worried or quite worried.

- “Earth has a fever” – let people know that they can help earth feel better.
- Develop educational materials, distributed online, for public health professionals – Paul's pres.
- Establish ownership of global climate as PH issue
  - APHA
  - NACCHO
  - Develop position paper

## RESOURCES/COLLABORATION

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- Dedicated state/federal/philanthropic initiatives
  - 40 states have Climate Action Plans
- Schools of public health and other academic institutions.
- New England Network of communities focused on energy and climate change through ICLEI.
- Have ICLEI facilitate collaboration between health departments and CCP lead agencies – at national conferences.
- Private interests (insurers/others)
- Nat'l Religious Partnership for the Environment
- DOE
  - Clean Cities
  - Technical Assistance
  - Financial resources
  - Willing to connect PH professionals to other decision makers

structure to monitor the sentinel climate-related health indicators.

- Research international monitoring, indicators, and policy.
- Model good energy policies and share case studies of preventative measures.
- Strengthen academic-health dept. partnerships.
- Develop web-based information sharing for this group, including draft educational materials.
- Maintain connection among participants.
- Connect with other cities already working on this, and include in conversation.
- Take a survey of public health dept. activities related to energy.
- Mobilize local health programs to develop clean energy policy and strategies.

### Action Steps

- Identify strategy to establish climate change as PH issue and institutionalize at ASTHO, NACCHO, APHA, CDC, Healthy People 2010, NIH (frame research priorities), Trust for America's Health (funded by Pew, gives annual report cards), IOM, etc.
  - Alonzo Plough is on NACCHO Board and Governing Group
  - May NACCHO mtg? Window of opportunity.
  - Write letter to Julie G., CDC
    - Atlanta can support
- Identify PH indicators that relate to global climate change.
- Convene a group to put pressure to broaden the bioterrorism surveillance funding for improving PH

# Appendix C: Municipal Climate Protection Measures

## Sample list of measures local governments can take to reduce GHG emissions

This is a sector-by-sector list of measures local governments can implement to reduce greenhouse gas emissions in their community and in their own facilities and operations. Use this list to identify existing measures to include in the Local Action Plan, as well as to brainstorm on new measures that can be enacted in the future.

### Community Measures

#### **Residential Sector**

- Building codes:
  - setting energy efficiency standards for new construction or major renovations
  - requiring light colored, high albedo rooftops and pavement
- Ordinance for energy efficient retrofit in existing building stock at time of sale
- Solar access ordinance



- Solar hot water/pool heating and solar PV applications, ordinance or incentives
- Passive solar design and solar orientation incentives, guidelines, ordinances
- Financial incentives e.g. tax incentives, rebates, loans, etc.:
  - for installation of photovoltaics, other renewable energy application
  - for more efficient appliances, e.g. refrigerators, lighting, water heaters
  - for improving efficiency in existing and new buildings
- Home insulation or weatherization program

- Distribute water saving devices, such as low-flow shower heads and faucet aerators
- Distribute compact fluorescent bulbs, other home energy saving devices
- Education and promotion of "cool communities" type landscaping
- Tree planting program to maximize shading of buildings

### **Commercial Sector**

- Building codes:
  - raising energy efficiency standards for new construction, significant renovations, remodeling, additions, other activities requiring permit
  - requiring light colored, high albedo rooftops and pavement
- Ordinance for energy efficient retrofit in existing building stock at time of sale
- Solar access ordinance
- Provide energy services to business, e.g. audits, assessments for energy efficiency improvements, other technical assistance
- Cooperative or aggregate purchase or buyer program for lighting, efficient equipment
- Distribute compact fluorescents, lighting occupancy sensors, other commercial application energy saving devices
- Lower business fees or waive permits for energy efficiency improvements and use of solar energy
- Building Energy Tax Credit

### **Industrial Sector**

- Ordinance establishing energy efficiency requirements for new industrial permits
- Ordinance requiring industries to develop and implement energy conservation programs
- Ordinance lowering business fees or waiving permits for energy efficiency improvements and fuel switching (including use of solar energy), heat recovery/co-generation systems
- Provide energy services to industry, e.g. audits, assessments to recommend process changes, other energy efficiency improvements

### **Financing**

- Establish financing program for efficiency improvements in the community, e.g. revolving loan funds through bonds, energy taxes, etc.

### **Transportation Sector**

- Implement policy shifting funding away from roads and highways to alternative transit
- Increase use of alternative transit - public transit, van-, carpooling, cycling, walking through:
  - Funding for facility, system and/or infrastructure improvements
  - Dedicated lanes for transit/HOV vehicles
  - Implement free bike share program
  - Work with transit authority to reduce public transit fares
  - Ordinance providing parking fee and road toll discounts for van- and car-pools
  - Jitney or shuttle service connecting neighborhoods to commuter lines
- Establish service center selling transit passes, coordinating car/van pooling, ridesharing, etc.
- Trip Reduction Ordinance or policies requiring or promoting programs to encourage use of transit, ridesharing, telecommuting, business-sponsored parking cash-out programs
- Establish solar PV or other electric vehicle charging station
- Establish or facilitate road tolls to decrease motor vehicle use
- Parking policies:
  - Implement program to remove public parking
  - Implement program of reduced parking fees for HOVs or high-MPG vehicles
  - Zoning ordinance that reduces minimum parking space requirements for new construction
  - Parking fees to fund transit use, bicycle or pedestrian improvements

### **Land use**

- Zoning or land use policy changes to promote infill development
- Zoning ordinance that promotes high-density development

- Zoning change to reduce parking requirements and allowances
- Density bonuses and incentives for high-density, infill, and transit-oriented development
- Impact, facility, mitigation, and permit fees that discourage sprawl

### **Waste Sector**

- Establish a center for reusing salvageable goods
- Home composting education program, compost bin distribution
- Collect curbside yard debris
- Implement or expand residential curbside recycling collection
- Improve or expand commercial recycling collection
- Community recycling drop-off sites
- Financial incentives to reduce waste such as:
  - Pay-as-you-throw or unit pricing
  - Special taxes and tipping fees
  - Advance disposal fees
- Implement landfill methane collection program

### **Measures affecting Gas and Electric Utilities**

- Purchase “green power” and specify renewable energy content for local government operations
  - Negotiate minimum standards for renewable energy portfolio
  - Negotiate aggregate purchasing contracts that specify renewable power for commercial and residential sectors
  - Implement program offering residents and businesses the option of purchasing renewable power for a surcharge
- Local Government Measures

### **Buildings**

- Comprehensive municipal retrofit of existing buildings, parks, stadiums, swimming pools and other recreation facilities, e.g. lighting, insulation, HVAC systems
- Building-specific renewable energy applications, e.g. installing solar hot water heating for locker rooms of recreational facilities
- Lighting efficiency improvements
- Energy efficiency standards for renovations and new construction of municipal buildings
- Lighten colors of existing rooftops and street paving to reduce “heat island” effect
- Rooftop gardens, greening of buildings surroundings for cooling
- Building-specific fuel switch from electricity to natural gas
- Implement co-generation or heat recovery
- Procurement policies that specify energy efficiency standards in all purchasing and bid specs for office equipment, motors, lighting, appliances, etc.

### **Lighting**

- Replace existing lighting with energy-efficient and low-wattage lamps and ballast
- Reduce energy use through reducing hours of operation and/or number of lights
- Solar Photovoltaic (PV) powered street and emergency lighting
- Switch traffic signals, exit signs from incandescent bulbs to Light Emitting Diodes (LEDs)

### **Procurement**

- Modify purchasing policies to specify energy efficiency standards in all purchasing and bid specs for office and heavy equipment, motors, lighting, appliances, etc.
- Purchase “green power” and specify renewable energy content for local government operations

### **Fleet**

- Downsize current and future vehicles through procurement policy changes
- Reduce fleet size, i.e. total number of vehicles
- Improve scheduling and route efficiency

- Change procurement policy to specify high fuel efficiency for each vehicle class
- Improve maintenance regime for increased efficiency, e.g. check tire pressure
- Replace on-the-job driving with telecommunications, transit, bicycling, walking, and car-pooling
- Provide incentives to reduce municipal employee travel, e.g. trip reduction policies like subsidized transit passes, elimination of free parking, preferred parking for carpools, vanpools

### **Water**

- Energy-efficient retrofit of facilities, especially pumping processes
- Energy-efficient specs for new construction of sewage and waste water system
- Improve energy-efficiency of equipment
- Process changes to improve energy-efficiency of treatment of drinking water, wastewater and sewage
- Change energy source from electricity to natural gas for existing operations

### **Waste**

- Increase office recycling, e.g., paper, cardboard, cans, toner cartridges
- Recover food waste in cafeterias and kitchens of local government buildings for composting or other use
- Waste prevention in day-to-day operations—two-side copying, reduced paper requirements, etc.
- Purchasing preferences for recycled materials
- Compost park, street, and other landscaping debris for re-use by Parks and Recreation
- Recover landfill methane for energy production

### **Others**

- Implement or participate in district energy programs, i.e. district heating and cooling
- Implement public education programs, e.g., special events, PSAs, curricula
- Implement urban forestry projects
- Establish energy efficiency or climate protection information clearinghouse.

## **ROOF GARDENS**



# Appendix D:

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## PARTICIPANT LIST

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City Health Directors' Policy Forum on Climate Change  
October 27-28, 2002  
Boston, MA

### Representatives from Health Departments

Mr. John Auerbach  
Executive Director  
Boston Public Health Commission

Mr. Alan Balsam  
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Medical Director  
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Mr. John Bolduc  
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Dr. Vincent Nathan  
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Ms. Sonia Hamel  
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Mr. Stephen Costa  
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**Boston Public Health Commission**  
**Attendees**

Ms. Sarah Meginness  
Project Manager, Healthy Cities Initiative

Ms. Kristin O'Connor  
Communications Director

Ms. Margaret Reid  
Director of Asthma Prevention and Control

Ms. Laura Melbin  
Education Manager, Bureau Comm.

Mr. Roger Swartz  
Bureau Director of Community Initiatives

## Remote hazards seen coming home

The Boston Globe 29 Oct 2002:A4

By Stephen Smith

GLOBE STAFF

In one city, community watchdogs backed by the public health agency issue informational warning tickets to drivers whose idling cars belch exhaust fumes. In another, medical leaders are pivotal in the drive to reduce pollutants by 10 percent. In a third, health authorities lead the charge for a light-rail system.

From cities as disparate as Miami and Seattle, public health commissioners gathered in Boston yesterday to better understand - and better combat - environmental changes that have contributed to outbreaks of disease, leaving millions of Americans wheezing or with life-threatening fevers.

Their goal is to demonstrate how seemingly remote issues, such as global warming and ground-level ozone levels, can relate to a child's asthma or a next-door neighbor's infection with West Nile virus.

"Consumers need to know about the link between health and climate, because we can change it," said Dr. Kevin Stephens, director of the New Orleans Health Department. "People may think their contribution is just one drop in the bucket. But if everybody puts a drop in, we've got a whole bucket of water."

And that is exactly what Louisiana could have used last spring, when drought swept a state better known for its swampy humidity. That drought, disease trackers believe, provided the foundation for an epidemic of West Nile disease in the summer.

Mosquitoes, epidemiologists found, congregated in storm drains, among the few sources of water available. But those drains are especially rich feeding grounds for mosquitoes. At the same time,

birds probably flocked to those same drains, also seeking water. That inauspicious confluence of bird and bug might well have ignited an outbreak that resulted in 317 human infections and 16 deaths in Louisiana.

West Nile and another mosquito-borne illness found recently in Virginia, malaria, provided an especially graphic example of how climate and disease interact in ways that can galvanize public health agencies to action.

That response, the health authorities agreed, too often comes after episodes of illness have begun. So, rather than swap war stories about outbreaks of the past, the health commissioners sought ways of detecting disease outbreaks before they begin and enlisting the public in steps to reduce the environmental forces that may contribute to health crises.

"If we tie it together for people, we make it less scary," said Lillian Shirley, director of the Multnomah County Health Department in Portland, Ore. "You figure out what's in it for them and how they can mobilize to effect change."

For public health, such forward thinking represents new terrain, which, in turn, will require new methods for measuring the threat to health posed by environmental factors. Among the recommendations to emerge yesterday was the establishment of early warning systems to detect changes in air, water, and food before they can produce potentially lethal diseases.

Public health departments, for example, might get more involved in measuring the quality of air and

water, looking for particulates in the breeze or organisms in the water that might be sentinels of impending illness.

"Too often," said John Auerbach, executive director of the Boston Public Health Commission, "public health will just deal with the symptoms and get people through the crisis and minimize the human harm. We, as public health departments, are just now taking baby steps to deal with the issue of global climate change."

Auerbach summoned public health executives from 15 cities and counties to Boston, representing places as big as New York and Los Angeles and as small as Milford, Conn.

They traded experiences with newly hatched efforts designed to make the link between environment and health.

In Boston, the public health commission awarded grants to community groups to ticket idling cars and sniff out salt piles that might be contributing to an epidemic of asthma. In Portland, Ore., the health agency had a prominent role in shaping the "Local Action Plan on Global Warming," with its key mandate of reducing carbon dioxide emissions. And in Houston, health executives championed the drive for improved mass transit.

"If we can reduce some of these environmental effects, we think we can reduce some of these environmental diseases," said Dr. Vincent Nathan, a deputy director in the Washington, D.C., Department of Health. "And isn't that what public health is all about?"

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